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AUTHOR Keller, Thomas E.
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ABSTRACT

A hands-on approach to science is highly desirable because an inquiry approach to science greatly promotes learning. However when students and teachers manipulate glassware, chemical, and other materials, accidents will happen. Because of this, risk management and safety procedures become an important, integral part of the science curriculum. This booklet presents the guidelines to having an effective safety program. Included are the following sections: (1) general safety instruction; (2) fire protection; (3) eye protection; (4) laboratory chemical inventory, disposal, storage, and labeling; (5) facilities; and (6) references. A student safety contract, safety rules for chemistry, biology, and physical science students, an explosives list, general housekeeping rules, and a list of resource personnel are appended. (KR)

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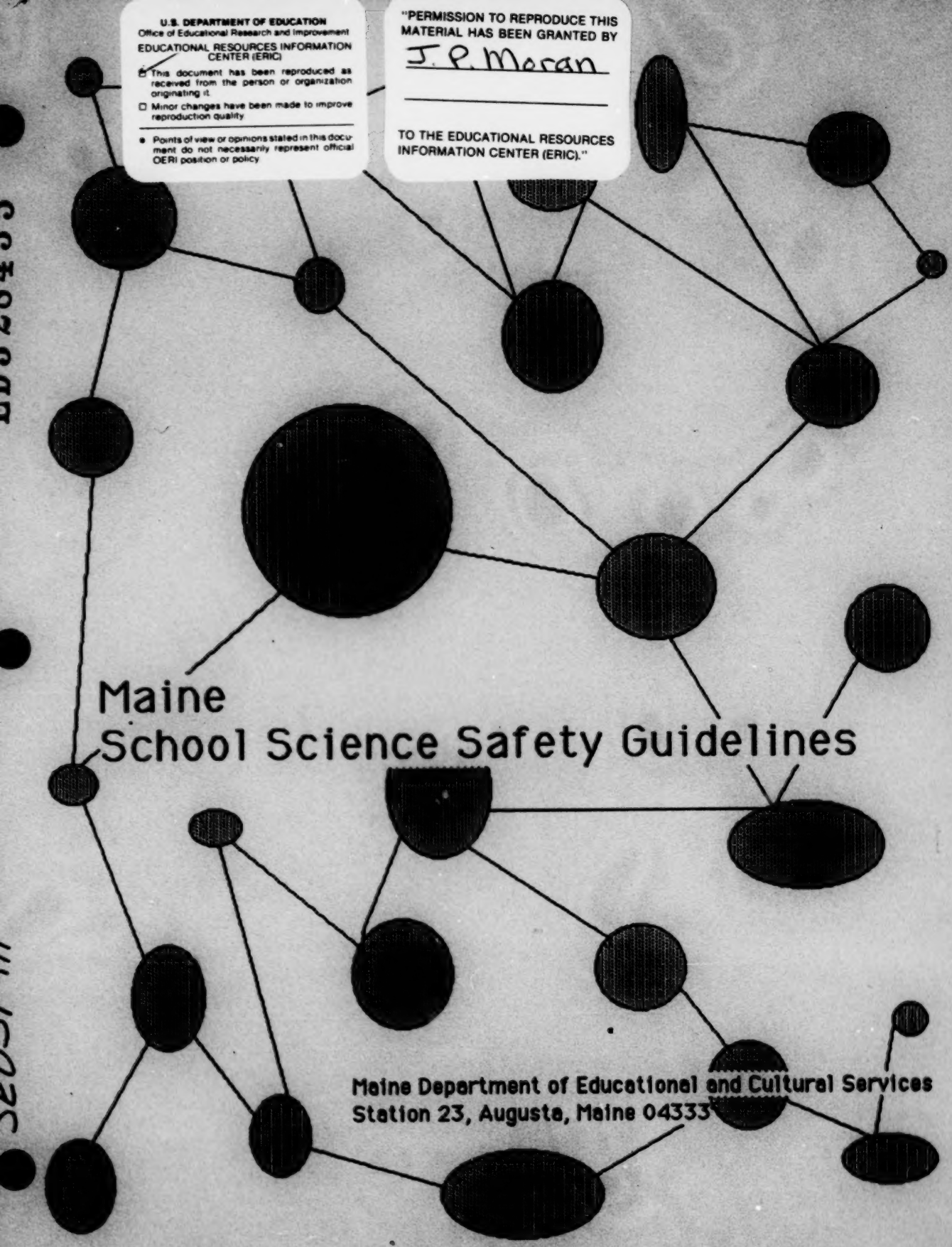

Maine School Science Safety Guidelines

Maine Department of Educational and Cultural Services
Station 23, Augusta, Maine 04333

MAINE SCHOOL SCIENCE SAFETY GUIDELINES

Table of Contents

I. Introduction

II. The Quick Answer

III. General Safety Instruction

IV. Safety Rules

V. Fire

VI. Eye Protection

VII. Eye Flushing Devices and Emergency Showers

VIII. Laboratory Chemical Inventory, Disposal, Storage and Labeling

IX. Facilities

X. Off-Premises Concerns

XI. Miscellaneous Areas of Concern

XII. References

XIII. Appendices

- A. Student Safety Contract
- B. Safety Rules for Students
- C. Explosives
- D. Housekeeping
- E. Resource Personnel
- F. Private Safety Consultants/Services

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Thomas E. Keller
Science Consultant
Maine Department of Educational and Cultural Services
State House Station 23
Augusta, ME 04333
289-5925

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I. Introduction

A hands-on approach to science is highly desirable because an inquiry approach to science greatly promotes learning. However equipment and materials are needed,and these cost money; also, when students and teachers manipulate glassware, chemicals, and other materials, accidents will happen. By having an effective safety program in place, risk management and safety procedures become important, integral parts of the science curriculum.

There are several agencies in Maine which are concerned with safety in schools. The Maine Department of Labor (MDOL) conducts annual inspections of Maine businesses and schools as the Occupational Safety and Health Administration (OSHA) agent. These inspections are quite thorough and rigorous. A report of alleged violations is sent to each superintendent and is to be posted for 10 working days where employees may see it. A recent addition to MDOL/OSHA inspections is compliance with Maine's Right To Know (CHEM-ID) law. This law requires that material safety data sheets on hazardous chemicals be available to employees, that a hazard communication report and procedure be established, and that employees receive training on the impact of this law. (For further information, contact Lester Wood, Director, Bureau of Safety, Maine Department of Labor at 289-2591.)

A second agency concerned with safety in schools is the Maine Fire Marshal's Office. This office conducts periodic inspections and examines items such as proper exiting, construction, and fire systems.

A third agency concerned with school safety is the Maine Department of Educational and Cultural Services (MDECS). MDECS involvement stems from sections of Chapter 125, Basic School Approval Standards and Chapter 127, Instructional Requirements and Graduation Standards. Adherence to appropriate regulations is examined during Basic School Approval visits which are conducted once every five years.

The legal aspects of liability, negligence and other issues are complex and require specialized understanding. School district attorneys are the most appropriate persons to answer specific questions regarding tort law or other concerns.

With recent discussions on classroom, laboratory and field trip safety and the problems involved with the disposal of unwanted chemicals, the question which frequently arises is, "Why teach any hands-on science?" The question should be, "Why teach hands-on science when unacceptable risks are involved?" For example, formaldehyde has been found to be a human carginogen. Thus it seems prudent to eliminate exposure to formaldehyde. If there are no other less harmful alternatives and the risk is determined to be acceptable, the decision is in the hands of the school. On another tack, consider the mundane experience of taking students on an outdoor field trip. Do you take appropriate precautions for students who may be allergic to bee stings, who are on medications which make them sunlight-sensitive, or who are hemophiliacs? Do you even know these things about the students going on the trip?

It is assumed that people will use their common sense regarding safety such as giving clear directions, not letting students taste chemicals, etc., and so these things are not discussed in these guidelines. Many topics may have been overlooked and this guide certainly should not be construed as the final word. It is expected that you will seek further information and maintain awareness.

II. The Quick Answer

The most immediate concern is chemistry stockrooms. Generally these rooms contain the accumulations of many teachers and some chemicals that appear to have been purchased in the early 1900's.

There are eight actions which must be taken as soon as possible by middle/junior high or secondary school chemistry teachers or science department heads. These are:

First, read these guidelines in their entirety.

Second, examine the science curriculum in your district and list the chemicals (including the amounts) you will need for this year and next.

Third, make an inventory of what you have throughout the district.

Fourth, decide what you want to keep or discard.

Fifth, properly store those chemicals you are keeping and compile the material safety data sheets.

Sixth, properly dispose of those chemicals you no longer want.

Seventh, make certain that fire extinguishing devices are available, appropriate and have been inspected within the past year.

Eighth, prepare for control of chemical spills by purchasing commercial spill control kits or kitty litter (without deodorant), plastic garbage bags, a plastic dustpan and broom, dry clean sand and a metal container, and use them when necessary.

III. General Safety Instruction

As stated in Chapter 127 Instructional Requirements and Graduation Standards (127.03 D.), instruction in safety shall be integrated into all relevant areas of the school program as a general requirement K-12. Science is certainly a relevant area.

Chapter 125 Basic School Approval (under 125.17 C.) states that "instruction in safety pertaining to all potentially dangerous activities conducted in school programs such as industrial arts, physical education, fine arts and science laboratories shall be the duty of teachers assigned

to the programs."

Instruction should include, but not be limited to, pre-investigation discussions, periodic safety training, and identification of hazardous situations.

Some teachers have found student safety contracts to be useful. These contracts document that the student has received training and clearly describe the areas covered. An example of a student safety contract is listed as Appendix A (page 16). This could serve as an outline for safety instruction, become a regular feature of student tests and should be retained by the teacher.

Simulating emergencies in addition to whole school fire drills may be prudent. School Science Safety (1985) suggests that the teacher, without prior warning, select a student to act out an emergency. The authors of this publication portray a situation in which a blindfolded student simulates a chemical splash to the eyes. With other class members protecting the "victim" from falls, etc., the teacher might ask the "victim" where is the eyewash station? Where is the teacher? How do you get to the eyewash station?

IV. Safety Rules

Safety rules must be posted in science labs, shops and home economics rooms. These can be as simple as posters purchased from commercial vendors to detailed descriptions on the use of particular pieces of machinery. A student safety contact should also be posted.

An elaborate set of safety rules, developed by the Maryland Department of Education, is provided as Appendix B (pages 17 - 21).

Each science room must have first aid supplies available but not necessarily in the science room itself. However, the teacher should have the school nurse or someone trained in first aid provide treatment. Policy should be developed to address how help is sought if a classroom teacher is injured.

V. Fire

School fire safety is an issue in all subjects K-12. Schools at all levels K-12 are required to hold two fire drills during the first two weeks of school. Schools housing grades K-4 will hold an additional eight fire drills during the year; schools housing grades 5-8, an additional six fire drills; schools housing grades 9-12, an additional four fire drills. Schools housing any combinations of these grade levels will hold the additional number of fire drills required of the lowest grade level within the span. Results shall be recorded and deficiences noted and corrected. Staff members shall receive an annual orientation in this procedure.

Fire exit instructions must be clear, concise and posted in an obvious location in each classroom.

Should a fire occur, the teacher's first response should be to send the students out of the room. Next, the fire alarm should be sounded.

Each teacher should know the location and operation of the fire alarm device. Third, contact the fire department. Emergency telephone numbers are required to be posted by all telephones as per MDECS Regulations Chapter 125.17B.

Teachers should check the location, condition, and type of fire extinguisher periodically, for example, on the first Monday of the month. If the extinguisher is discharged or missing, correct the situation immediately. Locations of extinguishers and fire blankets should be clearly and prominently marked. Each room in which laboratory study is conducted should have a 36 pound gross weight fire extinguisher.

There are four classes of fires. A standard tri-class (A/B/C) dry chemical fire extinguisher will handle all fires except metals such as sodium, potassium or magnesium (class D). A bucket of clean dry sand should be available and used to smother class D fires. Carbon dioxide (CO2) fire extinguishers can be used for materials other than class D metals. However, a CO2 extinguisher must not be used directly on people since frostbite from the dry ice generated is a possibility. Halon fire extinguishers are particularly effective for use around computers and are sized based on room volume.

Teachers should know how to use the extinguishers in their classrooms and schools. The local fire department or fire extinguisher service company can provide critical annual training that includes the use of extinguishers by teachers on actual fires.

Fire blankets should be available in each laboratory and storeroom. These should be mounted approximately 30 inches above the floor. Wool fire blankets are the preferred type.

VI. Eye Protection (Chapter 125.17 C)

Eye protective devices are required for all persons exposed to dangerous activities in shops and laboratories involving chemical or combined chemical-physical work, including the use of acid, caustic or explosive chemicals, or hot liquids or solids. These devices must meet the standards of U.S.A. Standards Institute Safety Code Z 87.1-1968 (or later designation) and be stamped with Z87 (found on the temple piece and lens).

Consider requiring that eye protective devices be worn when dissecting specimens in life science classes. Check the material safety data sheet for the preservative which was used and note the recommended precautions.

Eye protective devices that are shared by students must be sanitized prior to use. Cabinets which sanitize and store these devices are commercially available. Washing the eye protective devices in warm water and soap following each use could be a regular part of laboratory clean up.

In general, teachers and students should wear eye protective devices whenever chemicals and/or heat sources are used, with activities involving projectiles, or when solid materials are struck which may produce flying particles.

Opinion differs on the wearing of contact lenses in science laboratories. While contacts do not offer eye protection in laboratory situations, banning them is not practical. Wearing eye protective devices with contact lenses is essential.

VII. Eye Flushing Devices and Body Showers

Eye wash stations are required in rooms where laboratory chemicals are used or housed. According to DOL/OSHA requirements, they must provide 15 minutes of gentle and continuous irrigation of potable water to both eyes. The pressure and temperature must be regulated to maintain this irrigation requirement. The station should be located within a travel distance of 25 feet of any area where chemicals are used or stored and preferrable in the same room.

Portable eye-wash bottles CANNOT satisfy the above conditions. Portable bottles treat only one eye, can be tampered with, are infrequently cleaned and refilled, and do not provide 15 minutes of continuous irrigation.

An alternative to either the separate permanent eye wash station or portable bottles is a faucet-mounted eye wash. The advantages to this are low cost and the certainty of drain availability. The disadvantages are that pressure and temperature regulating devices must be installed.

It is recommended that science labs be equipped with a body shower or drench. This could be a shower/eye wash combination, a single emergency shower, or a simple plastic shower head on the end of a flexible hose. Temperature regulating devices should be installed in these also.

VIII. Laboratory Chemical Inventory, Disposal, Storage and Labeling

A. Inventory

Maintaining an inventory of chemicals housed in the building is essential. Copies should be kept by the teacher, the principal, and the central school office. The Maine Department of Labor (MDOL) requires that lists of chemicals be kept by the school district for twenty years.

If an inventory does not exist, create one. Proper planning should ease the creation of an inventory. For example, prepare a sheet with columns for the name of chemical, approximate amount, approximate age, and the supplier's name and address. The business department in your school may be able to transcribe an oral recording of this information. Decide who will do the inventory and inform someone outside the chemical stockroom when the inventory is being done. Make certain that safety equipment (goggles, gloves, fire extinguisher, etc.) are available to the person(s) doing the inventory and that they are properly qualified to conduct the inventory. Material safety data sheets which are required by the MDOL can be requested from the companies which supply the chemicals.

Be aware of the chemicals which can become explosive. These are listed in Appendix C (page 22).

The Flinn Scientific Inc. catalog lists many suggestions for the compiling of a chemical inventory.

The Maine Department of Labor (MDOL), Bureau of Labor Standards requires that substances which are not specifically exempted be listed with them. The substances which are exempt at present are:

A. Consumer products and foodstuffs packaged for distribution to, and intended for use by, the general public. This includes any labeled product used or stored in a workplace in the same form, approximate volume or amount, concentration and manner as it is sold to and used by the general public, provided that it remains labeled in the workplace, and to which, in the employer's knowledge, employee exposure is not significantly different from that of the general public during foreseeable use of the substance;

B. Substances sold by retail stores, for personal or domestic consumption, which are prepackaged, sealed, canned or otherwise contained so as to prevent worker exposure;

C. Common substances found in the workplace in small quantities that do not present a significant hazard to workers. Common substances include, but are not limited to, office desk top supplies, such as correction fluid, thinner or typewriter cleaning fluid, glues and cleaning solvents;

D. Petroleum distillates used as motor fuel or heating fuel;

E. Fire extinguishers in the workplace; and

F. Propane gas stored out-of-doors and used for commercial heating and cooking. (Chapter 22, Title 26 MRSA 1984 Public Law, Chapter 823).

All other chemicals must be registered with the Maine Department of Labor annually. An updated list must be maintained on the premises. The school district must keep these lists for twenty years.

In addition, the MDOL requires the implementation of a comprehensive hazard communication program, which includes container labeling and other forms of warning, compilation of material safety data sheets, and employee training.

The MDOL, Bureau of Labor Standards, is available to provide assistance to employers in the development and conduct of training programs for employees and local public safety personnel.

The development of an inventory leads to the next step which is to decide what should be kept or discarded. Laboratory chemicals which are not used in the usual curriculum or within a two year span should be discarded. The question becomes how to dispose of these materials.

B. **Disposal**

There are two basic options for disposal. The materials could be properly stored and left on site, or the materials can be removed from the site. This must be done legally and properly.

State mandates on chemicals in schools; a. prohibit uncoated asbestos and illegal drugs, b. require that all chemicals be stored properly, and c. require that those materials which are identified as wastes must be properly discarded.

At present, contracting with a chemical dispoal company is the only method of proper and legal disposal. Costs can be reduced by segregating wastes into specified categories, but chemical disposal is an expensive undertaking.

C. **Storage and Labeling**

The most common method of storage of laboratory chemicals is in alphabetical order. The booklet entitled Safety in Academic Chemistry Laboratories, published by the American Chemical Society in 1985, lists two pages of examples of incompatible chemicals, some of which would be placed next to each other if stored alphabetically. The Flinn Scientific, Inc. catalog lists thirty-five specific reactions of alphabetical chemicals. Reactions or explosions may result.

Several storage schemes are available and differ only in the detail of storage categories. The J.T. Baker Chemical Company has developed a color coding system to allow for identification of compatible chemicals. The Flinn Scientific, Inc. scheme extends this to further sort chemicals into compatible families. Both of these systems are described in School Science Laboratories: A Guide To Some Hazardous Substances.

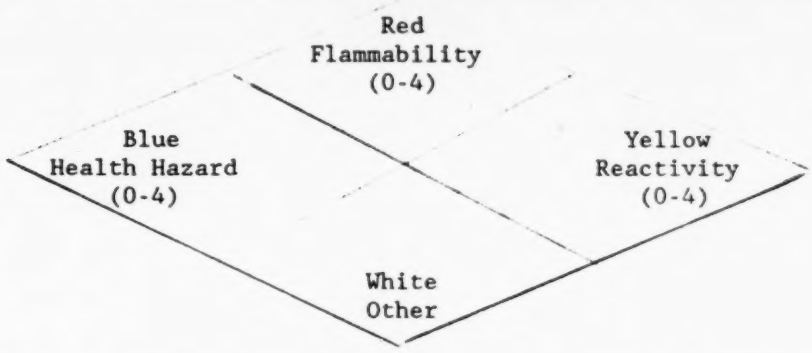
Acids should be stored in dedicated, labelled acid cabinets. It is recommended that nitric acid be separated from other acids.

Flammables should be stored in dedicated, labeled flammable cabinets. Some of these cabinets are manufactured fitted with vents. The National Fire Protection Association (NFPA) states that these fittings are provided to satisfy local ordinances in a few locations in the country and that unless this is a local ordinance in your area, these cabinets should not be vented.

Chemicals must be stored in locked rooms or cabinets where there is no student traffic. The chemicals should not be visible to non-authorized persons.

It is important that any vessel containing chemicals be clearly labeled. This applies to everything from plastic milk containers filled with a soap solution to an off-the-shelf bottle of nitric acid.

Where appropriate, the National Fire Protection Association (NFPA) hazard diagram should also appear on the container. This diagram is a diamond-shape which immediately identifies four categories of hazards. The following table is from How to Avoid Being Sued While Teaching Science:.



Signal Number	Health Hazard Blue	Flammability Red	Reactivity Yellow
4	Could cause death on short exposure.	Rapid vaporizing at atmospheric pressure.	Capable of explosive detonation.
3	Short exposure can cause serious residual injury even with prompt medical aid.	Liquids, solids can be ignited under almost all ambient temps.	With strong initiating source, heat or pressure, can react explosively. Violent reaction with water possible.
2	Upon intense or continual exposure, could cause temporary incapacitation.	Must receive moderate heat before ignition will occur.	Normally unstable and undergo chemical change readily, but do not explode. May react violently with water.
1	Exposure could cause irritation or minor injury.	Must be preheated before ignition can occur.	Normally stable but can become unstable at high temp. and pressure. May react with water, though not violently.
0	No more hazardous than normally combustible items.	Material will not burn.	Normally stable even under fire exposure and not reactive with water.

A "hazardous chemical" is defined by NFPA 45 as a chemical with one or more of the following hazard ratings: Health - 2, 3, or 4; Flammability - 3 or 4; Reactivity - 2, 3, or 4.

Teaching students the use and meaning of the NFPA Hazard Coding System is a meaningful topic for safety instruction.

IX. Facilities

Numerous agencies oversee all kinds of regulations regarding school facilities. Plumbing systems are the responsibility of the Maine Department of Human Services, Division of Health Engineering. Adherence to the Life Safety Code is overseen by the Maine Department of Public Safety, State Fire Marshal's Office. The architect of the original plans is required to design the facility according to the national building codes (or BOCA code). The Maine Department of Educational and Cultural Services has facilities requirements as contained in Chapter 125, which stipulate the following:

1. Safety rules be posted for operation of equipment (125.17)
2. Eye flushing devises be available (125.10)
3. Eye safety wear be available and sanitized prior to use (125.17)
4. There be no unguarded pulleys and equipment (125.10)
5. First aid supplies be available (125.17)
6. Flammable liquids be in approved storage (125.10)
7. Electrical outlets be grounded (125.10)

The following are school science facilities recommendations only and are most appropriate on the secondary school level. Those guidelines which also apply to elementary, middle or junior high schools have an asterisk.

CLASSROOM/LABORATORY FACILITIES RECOMMENDATIONS

1. The room has two exits.*
2. Doorways and aisles will accommodate handicapped students.*
3. Doors open outward.*
4. Doors have reinforced glass windows.*
5. There is a minimum of 35 square feet (4 square meters) per pupil for lab only and a minimum of 45 square feet (5.5 square meters) per pupil for classroom/lab combinations.
6. There are at least 9 feet (3 meters) of space between floor and ceiling.*

7. Work stations have slate tops or other coatings which are impervious to chemicals.

8. Air in the room is regularly exchanged (up to 4 room changes/hr) and mixed with outside air. The ventilation systems should be separate for the class/lab facility. *

9. Light level is 50 to 100 foot candles for each student work area.*

10. Exhaust hood is provided if extensive use of chemicals is involved. Hood venting (should draw 150 linear feet per minute) is clear to outside of the building and above window level of other rooms.*

11. The room has master shutoffs for gas, electrical, and water systems accessible by the teachers (and not in the storage/stockroom).*

12. Ground fault interrupters are provided for electrical circuits which are within six feet of water and all outlets are properly grounded.*

13. The room has a functioning intercom system or telephone for emergencies.*

14. An eye wash station (plumbed to a continuous and potable water supply with pressure and temperature regulation) with a drain must be no further than a travel distance of 25 feet.*

15. A body shower/drench (plumbed to a continuous and potable water supply with a mixing valve for temperature control and pressure regulation) with a drain must be no further than a travel distance of 50 feet.*

16. There are approved smoke/flame detectors strategically placed in the room.*

17. Floors are made of a durable covering with a nonskid wax.*

18. Water, both hot and cold, and sinks should be in all rooms in which science is taught.*

EQUIPMENT STOREROOM

1. All shelves are firmly attached to the floors and walls.*

2. The room has a functioning intercom system or telephone.*

3. There should be storage space specifically for science equipment.*

CHEMICAL STOREROOM/TEACHER PREPARATION ROOM

1. Ideally, the chemical storeroom should be located outside the walls of the school building.

2. Laboratory chemicals are to be stored in a separate room if possible; at least in a separate area.

3. Lockable fire doors separate the room from the school.*

4. Doors have reinforced glass viewing plates, if at all. Solid (no window) doors are preferred.*

5. The room has an independent, self-powered lighting system.

6. The room has a regular turnover (4 changes per hour) of air. There should be no chemical smells in the air. The ventilation system should be separate from that of the rest of the school, at or near floor level and run continuously all year.

7. There is a depressed floor drain which has a collar.

8. All shelves are firmly attached to the floors and walls.*

9. There is a smoke/flame detector with a remote alarm speaker outside the room.

10. There is a fire alarm box inside the room as well as near the door outside the room.

11. The room has a functioning intercom system or telephone.

12. The teacher preparation room should not double as an office.

13. An eye wash/face drench and body shower (plumbed to a continuous and potable water supply with a mixing value for temperature control and pressure regulation) with drains be provided.

14. Proper temperature controls for the chemical storage area be installed.

15. Space should be allocated for an acid storage cabinet and a flammable storage cabinet.

16. The room has two doors.

17. All vessels containing chemicals must be labelled.*

X. <u>Off-Premises Concerns</u>

Teachers often take students out of the classroom for a variety of educational experiences. The value of a well-planned trip far exceeds the efforts required in preparation, but those preparatory efforts must be undertaken.

Most school districts have a policy concerning field trips and this must be followed. Frequently policies involve having permission forms for individual trip use, informing parents of the purpose of the trip, and having parents give written permission for their child to go on the trip.

(It is advisable to ask if a child has any allergies which require critical attention.) However, such forms do not absolve teachers from responsibility while on field trips.

If at all possible, the teacher should visit the site before hand. This would help plan for physical orientation, hazards identification and for the most effective instructional use.

XI. Miscellaneous Concerns

A. Blood Typing

Policies concerning any procedure which breaks the bodies integument should be developed for times such as if blood is drawn in life science classes for blood typing. These experiences, if used, should be examined for appropriateness in the curriculum. Parental permission should be obtained prior to this experience. Sterilizing equipment and disinfection of the target area lowers the chance of infection. The target area should be washed with a chemical germicide and swabbed with 70% (or greater concentration) alcohol prior to puncture. Instruments that penetrate the skin should be discarded after a single use in a peroxide solution. The area should be covered by a bandage until the bleeding has stopped entirely.

A simple but effective disinfectant can be made with chlorine bleach and water, on a daily basis, in a 1 part water to 10-100 parts chlorine bleach solution according to Kathleen F. Gensheimer, M.D., of the Maine Department of Human Services (as reported in the School Nurse Exchange, August 1988, Maine Department of Educational and Cultural Services).

B. Housekeeping

Essential to an effective safety program are good housekeeping practices and clean work areas, which are further discussed in Appendix D.

C. Sources of Infection

The introduction of unwanted substances into the body must be avoided. The most common routes of this are through the mouth, nose, or skin. All procedures must be carefully examined, especially if these three routes may be involved. Mouth pipetting of any substance should be forbidden in school science labs. Accidential syringe injections or inhalation of spray from syringe "squirt guns" must be prevented. Inoculating loops could break and disperse the drop as an aerosol, releasing cultures of potentially harmful microorganisms.

XII. References

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18. Reduction of Hazardous Waste from High School Chemistry Laboratories, Pollution Prevention Pays Program, North Carolina Department of Natural Resources and Community Development, Raleigh, NC 27603.

19. Storing and Disposing of Chemicals: A General Guide, Sept. 1988, R.C. Fort, Jr., Chair, Department of Chemistry, University of Maine, Orono, ME 04469

* Available for examination from Thomas Keller, Science Consultant, Maine Department of Educational and Cultural Services, State House Station #23, Augusta, ME 04333, tel. # 289-5925.

Appendix A

Student Safety Contract

This is to certify that I, _____ have been apprised of the following safety components of this science class:

1. Safety rules _____

2. Location and proper use of the following safety equipment

   a. Fire extinguisher _____
   b. Fire blanket _____
   c. Eye protective devices _____
   d. Eyewash _____
   e. Deluge/drench shower _____
   f. Chemical dispensing containers _____
   g. NFPA chemical labeling system _____
   h. Master shutoff for gas, electricity, water _____
   i. Heat sources (bunsen burner, alcohol lamp, microwave oven, coffee pot) _____
   j. First-aid kit _____
   k. Electrical equipment _____
   l. Emergency telephone listing _____
   m. _____
   n. _____
   o. _____
   p. _____

3. Safety procedures for the following situations:

   a. Fire _____
   b. Chemical splash to the body _____
   c. Eye emergency _____
   d. Chemical spill _____
   e. _____
   f. _____
   g. _____

Date _____ Teacher _____

From How To Avoid Being Sued While Teaching Science, Gerlovich et al., 1986

Appendix B

Examples of safety rules for science, taken from the Maryland School Science Safety Project Safety Manual K-12, are as follows:

"SAFETY RULES FOR STUDENTS

1. For All Sciences

- Wear safety goggles and laboratory aprons whenever directed by your teacher. Tie back long hair when dealing with chemicals and heat sources.
- Don't wear loose or bulky clothing. (This includes winter coats. Do not wear rings or other jewelry that may be exposed to chemical reactions or catch on equipment or allow chemicals to be trapped in contact with skin.)
- Know the location of safety and first aid equipment, including fire extinguisher, safety shower, fire blanket, and eye wash.
- Wear suitable footwear (no open-toed shoes or sandals).
- Horseplay or other acts of carelessness are prohibited.
- Dispose of water properly. Do not put matches in the sink. Broken glassware should be discarded in proper containers.
- Never eat, smoke, or drink in the laboratory.
- Never drink from laboratory glassware.
- Notify the instructor when you observe hazardous conditions in the classroom.
- Examine equipment for malfunction, cracks, or other defects before beginning.
- Report all accidents, no matter how minor, to your teacher immediately.
- Know and understand possible hazards for each experiment before doing them.
- Perform only authorized and approved experiments.
- Follow instructions explicitly.
- If at any time you do not understand an experimental procedure, ask questions of your teacher.
- Always prepare for an experiment by reading the directions BEFORE you come to the laboratory.

- Set up equipment away from table edges, so it cannot be tipped on the floor.
- Use a water bath or hot plate to heat volatile and flammable liquids.
- Never apply a direct flame to a container which contains volatile or flammable materials.
- Tampering with gas valves when they are not in use may cause the valves to become clogged or loose, allowing gas to leak into a cabinet and/or the classroom.
- Check all Bunsen burner hose connections for pinching, loose connections, and leaks before lighting.
- Do not allow the gas to accumulate before igniting the Bunsen burner. Light the Bunsen burner immediately.
- When using matches to light a Bunsen burner, bring the match up the side of the burner and across the top to avoid extinguishing the match flame.
- Do not lean toward or reach across a flame.
- Turn off the gas if the gas "flashes back" or burns at the base of the Bunsen burner.
- Never leave anything unattended while it is being heated or is reacting rapidly.
- Remember that the Bunsen burner barrel remains hot for some time after use.
- If wing tops (flame spreaders) are used, allow time for these to cool before removing them from the Bunsen burner.
- Turn off gas valves before leaving work area.
- Test the temperature of an object by holding the back of your hand close to the object before attempting to pick it up.
- Use beaker tongs to handle hot beakers.
- Keep laboratory areas and all implements clean, neat and orderly.
- Care should always be considered when dealing with sharp objects. Scissors, teasing needles and knives should be used with extreme care.
- Don't place thermometers where they are likely to roll or be knocked off a table. Do not use excessive force when inserting thermometers into rubber stoppers. Always use an appropriate lubricant (and several layers of cloth or paper toweling). Make sure you choose a thermometer with an appropriate temperature range. Overheating a thermometer can cause breakage of its reservoir.

Report broken thermometers immediately--mercury vapor is extremely hazardous. (Thermometers filled with less hazardous substances can be purchased).

- Be careful when working with pressurized or evacuated containers such as bell jars, vacuum tubes, gas cylinders and thermos bottles. Breaking these containers can cause explosions or implosions with flying debris.

- Avoid electric shock or injury by:

  a. pulling the plug and not the wire when disconnecting power cords.

  b. keeping work areas, hands and feet dry when working with electrical apparatus.

2. Additional Rules for Chemical/Biological Sciences

- Wash hands after all spills and at the end of each lab period.

- Read all labels twice before using any chemical.

- Never return excess reagents to the stock bottle; discard any excess according to approved procedures.

- Never mix chemicals together unless the teacher or experiment has indicated you to do so.

- Never taste chemicals.

- Always add acid to water (with vigorous stirring), not vice versa.

- Aim open test tubes away from yourself and other students. Use splash caps if available.

- Never look down into a test tube containing a reagent or hot substance.

- Use a ventilation (fume) hood for any experiment that may generate hazardous or irritating fumes.

- To smell a chemical, gently waft (wave) the fumes toward your nose with your cupped hand.

- Never assume glassware is clean; wash at the beginning and end of each lab period.

- Corrosive reagents should be poured from their containers using a pouring rod. If chemicals drip down the sides, clean the bottle before picking it up.

- Do not clamp test tubes or flasks more tightly than necessary to hold them in place when heating. Expanding glass may break if clamped too tightly.

- Be careful with reagent bottle stoppers. Exchanged stoppers or stoppers placed near a spill could have unexpected and dangerous results when returned to the wrong bottle.

- Glass wool and steel wool should be handled carefully. It is advisable to cut the desired amount from the bulk supply with scissors or shears rather than trying to pull it off. It is easy to be cut by steel wool, and glass wool splinters in the skin can be very painful. Furthermore, teachers should caution students that steel wool is flammable and should not be exposed to open flames.

- When using pipettes, the pump action bulbs should be used. Do not pipette by mouth; the potential for aspirating the material is great. Also, remember that pipette tips and mouthpieces can be easily broken, resulting in severe cuts of the hand and fingers.

- Never set hot glassware on cold surfaces or in any other way change its temperature suddenly, because uneven contraction may cause breakage.

- When cleaning glassware, under teacher's supervision, a final rinse with acetone or alcohol may be used to enhance evaporation. Be sure the acetone or alcohol is completely evaporated. Make sure there is adequate ventilation. When placed near a flame, even a small amount of vapor can cause a serious explosion.

- When placing liquids in bottles for storage, allow about 5 per cent of the volume as air space to allow for expansion due to temperature changes.

- Any glass apparatus that is to be heated should be pyrex and free of chips and cracks. Graduated cylinders, reagent bottles, stirring rods, and tubing are usually soft glass and should not be heated.

- The ends of a glass tube may have sharp edges. These edges can be smoothed by fire-polishing. To fire-polish a glass tube, hold the glass so that the sharp end is in the top of the flame of a gas burner. Rotate the tube so all sides are heated evenly, causing the sharp edges to melt and become smooth. Place the glass on insulating material to cool. Bending glass tubing is often necessary. Place a wing-top attachment on a gas burner and heat the area of the glass to be bent while holding it with one hand on each end, rotating to ensure even heating. When the glass is soft and pliable, remove it from the flame and quickly bend to the desired shape. Results will improve with practice. Place on insulating material until cool.

- Always lubricate glass tubing when inserting into rubber stoppers. This rule applies to tubing, rod, thermometers, tubes and all other glassware. Glycerol or water is an appropriate lubricant. Aim the rod or tubing away from the palm of the hand holding the stopper. Always protect hands with gloves or cloth when inserting or working with glass. Wear suitable eye protection. Also ask your teacher to consider the use of commercial tubing inserters (or manipulators).

- Do not try to cut through glass tubing with a file. It will shatter at the point of pressure and may injure you. To cut glass tubing lay the tubing on a flat surface and make a single scratch with a file or cutter across the tube. Grasp the tube with both hands (make sure they are covered with a cloth) so that the scratch is on the outer side, your fingers circling the tube with the thumbs meeting on the opposite side behind the scratch. Snap the tube sharply by pushing outward with the thumbs and pulling back with the fingers. The tube will break along the scratch mark.

- Fingers should never be used to pick up broken glass. A whisk broom and dustpan should be used. Fine particles can be picked up with wet paper toweling.

3. Additional for Physical Sciences

   - Keep yourself and your clothing clear of moving (including rotating) objects.

   - Be careful when working with large magnets, elevated masses, and springs to prevent injury from unexpected motions.

   - Avoid electric shock or injury by:

     - treating all circuits as if they were energized.

     - making sure power is off when connections are made. (Test prior to connecting and test tester before and after each use.)

     - never short-circuiting a battery.

     - making sure capacitors are discharged before working on circuits containing them.

     - being aware of situations where high voltage is present (examples - induction coils, Tesla coils, transformers, cathode ray tubes, gas discharge tubes).

   - Steam (which is invisible) can produce serious burns. Never direct a steam source toward anyone.

   - When observing ultraviolet, infrared, or laser light, follow precautions indicated by the teacher as each of these may be harmful to the eye. Never look directly into a laser beam or its direct reflection."

Appendix C

Explosives (from School Science Laboratories: A Guide to Some Hazardous Substances, 1984)

CAUTION: This is not a comprehensive list of all possible explosive chemicals.

The substances in this table are NOT recommended for use or storage in schools, except as indicated, unless an absolute need is determined and appropriate safety procedures are instituted.

REMOVAL: Explosives should be removed by trained fire or police bomb squads, or other qualified officials. Limit movement of containers of such chemicals in order to minimize the chance of detonation.

SUBSTANCE	CAS No.
Benzoyl Peroxide	94-36-0
Carbon Disulfide (see note 1)	75-15-0
Diisopropyl Ether (see note 2)	108-20-3
Ethyl Ether (see note 2)	60-29-7
Picric Acid (see note 3)	88-89-1
Perchloric Acid (see note 4)	7601-90-3
Potassium metal (see note 2)	7440-09-7

1 The flashpoint of carbon disulfide (-22 degrees F) is well below room temperature and small amounts of the vapor in air can be explosive.

2 These chemicals become dangerous upon aging. Ethers and potassium metal can both form explosive peroxides upon exposure to air. Old opened containers of ether should be treated with great caution as should potassium metal not stored under kerosene.

3 Picric acid should always contain 10-20% water and bottles should be disposed of after two years. Dry picric acid is explosive.

4 Although the 70% acid/water mixture is not explosive by itself, the use of perchloric acid often leads to the formation of perchlorates which are very explosive.

Appendix D

"HOUSEKEEPING

Good housekeeping and a clean work area (with a place for everything, and everything in its place) are essential to safe laboratory performance. An orderly work area with clear aisles and a ready access to reagents is insurance against accidents.

In those laboratories equipped with stools, the students should be indoctrinated to keep the stools with the four legs solidly on the floor and never to sit with the stools tilted.

Spills should be cleaned up immediately using plenty of water to dilute the chemical and render it harmless. Sodium bicarbonate should be used to neutralize intensive spills of strong acids. Spills on the floor are especially dangerous, and the floor should be mopped DRY after cleanup to minimize the danger of slipping and falling. The outside of bottles containing strong reagents should be flushed with water frequently to prevent the contact of spilled chemicals with the hands.

Label shelves, cabinets, or drawers so that equipment can be easily found and returned.

A rigid program of cleanup at the end of the laboratory period should be instituted at the outset. Plenty of time should be allowed for cleanup and adequate warning given so that a thorough clean up can be accomplished without rushing.

Clean up all spills and bottle rings immediately.

Cleanup can make or break a laboratory program. It is imperative that the room be cleaned up and put back in order at the end of EACH period, not just once at the end of the day, or when you can no longer stand the mess. Classes entering a messy lab tend to work sloppily and leave the lab in worse shape at the end of the period. A number of factors contribute to efficient and relatively stress-free cleanup periods.

1. Insist on proper cleanup from the very first lab.

2. Make each person responsible for his or her own area and materials, but don't hesitate to ask students to help each other as well. Likewise, help them and ask that they help you.

3. Assign individuals or teams to take charge of common areas and to check on the return of various items.

4. Scan common areas such as the sink and supply tables several times during the period. If things are unsatisfactory, stop the whole class right away and have the mess cleaned up before allowing anyone to continue regular work.

5. Store glassware on drying racks or open shelves. Let nature evaporate the water. This saves time and paper towels.

6. Plan for cleanup time in the regular lesson schedule.

7. Use plenty of labeling. Label shelves and trays, so students can tell where to return materials after forgetting where they got them.

8. Have everyone return to seats after cleanup. Then take a minute to scan common areas, desks, lab benches, sinks, and equipment. Don't dismiss anyone until **ALL IS IN ORDER**.

9. Don't forget the compliments. If things look good or cleanup was quick and efficient, reward the students by letting them know you noticed.

Lab benches and tables should be scrubbed frequently so that spilled chemicals will not injure either the students or equipment, and apparatus must be clean and orderly. The possibility of the residue of one experiment being present in apparatus when the next experiment is conducted must be eliminated. The combination of chemicals might prove dangerous.

Fragile or bulky equipment should not be stored in a manner that increases the changes of brushing or jarring it off the shelf. Shelves with lips are recommended for equipment storage.

Cabinets and drawers should be closed when not in use.

Arrange seats to allow safe exiting in the event of emergency. Aisles should be unobstructed. Paths to safety equipment such as fire extinguishers or safety blankets should not be blocked.

Deposit wastes in appropriate receptacles. Do not pour flammable materials into the sink. Keep sinks clean at all times."

From the Maryland School Science Safety Manual K-12.

Appendix E

Resource Personnel

1. Maine Department of Labor
   Bureau of Labor Standards
   Division of Safety
   Lester Wood, Director, 289-6460
   Lance Gurney, Chemical Right-to-Know Coordinator, 289-6460
   Jane Garland, Industrial Hygenist, 289-6460

2. Maine Department of Public Safety
   State Fire Marshal
   Donald Bisset, Fire Marshal, 289-2481

3. Maine Department of Environmental Protection
   Bureau of Oil and Hazardous Materials Control
   Division of Licensing and Enforcement, 289-2651

4. Maine Department of Educational and Cultural Services
   Bureau of Instruction
   Division of Curriculum
   Thomas Keller, Science Consultant, 289-5925

Appendix F

(This listing does not imply endorsement of these individuals or businesses.)

1. Maine Center for Educational Services, ChemSafe Project
   A. James Fiske-Director, Dr. Clair Wood-Consultant, 223 Main Street
   P.O. Box 620, Auburn, ME 04210, 783-0833

2. Laboratory Safety Workshop
   Curry College, Milton, MA 02186
   Dr. James Kaufman, Director, 617-33-0500 x 2220

3. Schoolsafe Associates
   Robert J. Walter, 30 Eastern Avenue
   Boothbay Harbor, ME 04538, 633-2186